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TRENDS AND TECHNIQUES

FOR

SPACE BASE ELECTRONICS

(NASA-CR-161279) A STUDY OF TRENDS AND TECHNIQUES FOR SPACE BASE ELECTRONICS Final Quarterly Report, 11 Dec. 1978 - 10 Mar. 1979 (Mississippi State Univ., Mississippi State.) 23 p HC A02/MF A01 CSCL 09C G3/33 18688
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Prepared for

George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812

by

J.D. Trotter
T.E. Wade

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Mississippi State University
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Mississippi State, Mississippi 39762

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QUARTERLY REPORT

December 11, 1978 - March 10, 1979

CONTRACT NAS8-26749

TRENDS AND TECHNIQUES

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16. ABSTRACT

The technical contributions as outlined in the Scope of Work for this contract will be described in detail in the Final Report presently under preparation. This final quarterly report will present the microelectronics research and teaching capabilities which presently exist at Mississippi State University.

17. KEY WORDS Microelectronics laboratories Integrated circuit laboratories Laboratory, MSU	18. DISTRIBUTION STATEMENT

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MICROELECTRONICS AT MISSISSIPPI STATE UNIVERSITY

A. Introduction

The new microelectronics facility at Mississippi State consists of approximately 6600 square feet of space located in the newly constructed (1977) Harry Charles Fleming Simrall Electrical Engineering Building. The space and equipment represent a million dollars investment. Approximately 3000 square feet consists of class 10,000 clean rooms. Within this space, facilities exist for mask-making and photolithography, for chemical preparation, oxidation, etching, diffusion of impurities, for metallization, die-bonding and lead attachment, and for the evaluation of device and integrated circuit parameters. In addition, the hybrid facilities allows fabrication of thick and thin film circuits and encapsulation. Close research ties with NASA Marshall Space Flight Center makes available to EE students and faculty additional research tools, including scanning electron microscope, Auger analysis, electron microprobe, etc.

The vast field of solid state electronics has experienced radical changes since the invention of the transistor in 1949, and the invention of the integrated circuit in 1959. Today's hand held calculator, for instance, contains more than 50,000 active solid state devices on a single substrate (called a "chip"); electronic watches and appliances touch every aspect of our daily lives.

The rapidly changing technology which has made such electronic marvels possible poses a continuing challenge to an electrical engineering faculty not only to keep abreast, but to devise a curriculum which passes such knowledge on to students, both graduate and undergraduate, and to motivate them in a manner adequate to enable them to join that technology as actively contributing graduate engineers. To this end, the Electrical Engineering Department at Mississippi State University has recently established an extensive laboratory facility and revised curriculum aimed at meeting the threefold purpose of transmitting knowledge through teaching, at the undergraduate and graduate levels; opening new frontiers through research; and extending these efforts and findings to others through service.

Success in these endeavors depends on several important ingredients:

1) A dedicated faculty possessing interest and expertise in the various areas of physical electronics.

2) An undergraduate curriculum devised to teach students not only fundamental principles of physical electronics and of solid state electron devices, but also of the technology which is used in their realization. Students should be provided the opportunity to achieve "hands-on" experience in device fabrication.

3) A graduate teaching program offering education which enables students to do practical design and creative research contributing to the state-of-the-art.

4) A comprehensive research program which simultaneously provides for the education of advanced students while contributing knowledge, basic and applied, to the advancement of the field.

5) The availability of adequate laboratory facilities to support both teaching and research activities.

B. New Electrical Engineering Facilities

The Harry Charles F. Simrall Electrical Engineering building was completed in January, 1977, consisting of 95,000 square feet of floor space at a construction cost of 4.25 million dollars. This building was built under the direction of the State of Mississippi Building Commission with funds appropriated by the State Legislature.

The general theme of the building is classrooms, computer terminal and other heavily populated areas on the first floor, department offices and student activity areas on the second floor with teaching and research laboratories on the third and fourth floors. The features of the Harry Charles F. Simrall Electrical Engineering building include:

1) 10 classrooms with 382 seats total.

2) Computer terminal operated by computing center housing 1004 terminal and other special purpose equipment.

3) 254 seat Auditorium.

4) Microelectronics laboratory complex for instruction and research.

5) High voltage laboratory complex for instruction and research and testing.

6) Computer design and application laboratory complex for instruction and research.

7) Dedicated laboratories for instruction and research in control systems, microwave systems, communication systems, and electronic systems.

8) Dedicated instructional laboratories for study of digital devices, networks and electronics.

9) Student activities and organization area.

10) Faculty and Departmental office complex.

The building now houses all programs and activities of the Electrical Engineering Department which have previously been housed in parts of five buildings.

The Electrical Engineering Department includes 26 faculty members, some with duties outside the department, 410 undergraduate electrical engineering students, 42 undergraduate electronic engineering technology students and some 45 electrical engineering graduate students for a total enrollment of some 500 students.

C. Microelectronics

The objectives of the microelectronics program at Mississippi State are consistent with the University charge to provide education, research and service. These objectives are:

1) To provide an outstanding facility for research dealing with the electronic properties of materials, electron device research, circuit fabrication technology, and computer aided design of electronic circuits.

2) To provide circuit technology accessible at several levels of sophistication which will support research and teaching activities within the department, college and University.

3) To provide a facility available for prototype development of electronic apparatus by industrial concerns and to provide an expertise in electronic fabrication technology to assist industrial start-up operations.

4) To provide operational strategies to allow utilization of the facilities on an economically feasible basis consistent with the commitment to supporting agencies.

The SCOPE of the developing facility is detailed below:

I. Fabrication and processing capability

  A. Silicon Integrated Circuit

    1. Thermal oxidation and impurity diffusion

    2. Photolithography

    3. Chemical vapor deposition

      a. Polysilicon

      b. silicon dioxide

      c. other (phosphosilicate glass, silicon nitride, etc.)

    4. Aluminum film deposition

      a. sputtering

      b. E-beam evaporation

    5. Expitaxial silicon

    6. Ion-implantation

  B. Hybrid Integrated Circuits

    1. Thick film screen printing and firing

2. Chip and wire bonding

3. Component trimming

4. Substrate scribing

5. Packaging and encapsulation

C. Printed Circuits

1. Board sensitization, exposure, and development

2. Baord etching and drilling

3. Board plating

4. Board lamination

II. Computer Aided Design

A. Art work generation by computer

1. Printed circuit layout from line drawing

2. Custom art work for hybrid and monolithic IC's

3. Art work from cell librairies and layout programs

B. Art work processing

1. Reduction

2. Step and repeat reduction of IC master masks (presently thru NASA)

3. Development of working masks

C. Circuit Analysis

1. PCAP

2. Nonlinear circuit analysis program

3. Digital logic and timing analysis

III. Experimental Evaluation

A. Electrical: C-V, sheet resistance, curve tracing, probe testing, circuit testing.

B. Electrochemical: lap and stain, anodization

C. Optical: Microscopic, interferometric, ellipsometric

D. Surface analysis: SEM with SIMS or Auger attachment (presently thru NASA)

D. Description of Facilities

As indicated earlier, the new $4.25 million Harry F. C. Simrall Electrical Engineering Building became occupied in January of 1977. In the electronics area, the department owned or had custody of approximately $250,000 worth of equipment related to microelectronics prior to moving into the new facilities. Primarily the existing equipment consisted of that furnished by the state (mostly in the in the past 3 to 5 years), surplus equipment from NASA, much built in-house, and GFE items.

The microelectronics facilities are located on the fourth floor of the building and consume in excess of 6,600 square feet. Approximately 3,000 square feet of this consist of class 10,000 clean rooms. At a conservative building cost of $45 per square foot, this represents approximately a $300,000 investment in floor space alone. In addition, the department either has purchased or is in the process of purchasing some $175,000 worth of new equipment to furnish the microelectronics laboratory and associated supporting labs. Thus, a total commitment by the University of well over a half million dollars is being invested in this area for purposes of fundamental research and teaching. In addition, equipment obtained through industrial donations represents well over $350,000 to date.

Through University acquisition and industrial donations, the department will be equipped to do significant research in silicon integrated circuits, thick film and chip hybrid circuits.

The following describes the fourth floor microelectronics laboratories and related support facilities. All rooms have compressed air, vacuum, chemical drains, and extensive venting for safe and convenient operation.

A. Silicon Fabrication

This activity is to be carried out in three different rooms, all class 10,000. The water supply consists of an evaporation still, a storage tank with ultraviolet light source, a deionizer, and submicron filters for delivering a minimum of two gallon/minute of 15-18 megohm/cm. water.

A1. Process Room

This large 30 x 40 foot room has one fume hood with etching sink and D. I. water. Benches and cabinets and a quartz/mullite tube closet are also included. There exist five vented gas bottle closets capable of storing ten large cylinders. Water, drains and 3-phase power are available for furnaces and reactor equipment. The basic equipment includes:

. Thermco Spartan 6-tube furnace with class-100 load station and source cabinets.

. Three single tube furnaces (Lindberg, Marshall and BTU), all with electronic controls.

. One class 100 clean bench

- Vaponics deionized water system with additional reservoir for continuous cycle filtering
- Wafer dicer
- Unicorp. Inc. Unipole VIII Epitaxial reactor with dual 8" susceptors driven by a LEPEL solid state power supply (143KVA)
- Four point probe
- Lap and stain facilities
- Ellipsometer/Laser source
- Microscopes
- Multiple probe station
- Capacitance-Voltage test station
- Anodization equipment
- Large dewars for liquid nitrogen and liquid oxygen

For the furnaces, two tubes will be equipped to operate as hot-walled low pressure CVD reactors. The remaining tubes will be used for diffusion and oxidation. One or more tubes will be available for non-silicon work.

A2. Photolithographic Room

This room is 10 x 24 feet and is equipped with three in-line class 100 clean benches and two pass-through ovens with nitrogen ambients. All photo resist and developing operations are done in class 100 environment. Photo-resist spinning is done under temperature and humidity control. Oxide etching and wafer washing is done in end stations with high quality water. Other equipment includes:

- Two-head spinner, plus a single-head spinner

- Electroglass mask aligner for 1 1/2" wafers, plus two Casper aligners for 1 1/2" to 3" wafers
- Balance table's
- Interference microscope
- Hot plate/stirrers, etc.

A3. Metalization and Bonding Room

This large 30 x 20 foot class 10,000 clean room if for the deposition of metal films and thermal-compression bonding. It is equipped with compressed air, vacuum, D. I. water and chemical drains. Pertinent equipment includes:

- NRC-Varian 6" diffusion pump vacuum station equipped with a Sloan sputtering system and a thickness monitor
- Hughes pulse tip thermal compression bonder
- Class 100 clean station for bonder
- Varion Vacion vacuum station equipped for thermal evaporation of aluminum including film thickness monitor and class 100 clean station
- Class 100 clean benches for multiple probe station and vacuum system work areas
- Work benches and cabinets
- Large dewars for liquid nitrogen
- A 200 KeV ion implanter is to be added to this room in early 1979.
- Perkin-Elmer Vacion vacuum station equipped with dual E-beam guns for depositing alloys.

B. Hybrid Fabrication

This activity will be carried out in one large 48 x 42 foot room equipped with fume heads, sinks compressed air, vacuum and three-phase power. Ample bench tops and storage cabinet space is also available. Equipment includes:

- Thick film screen printer
- Class 100 clean bench for printer
- Drying oven
- Thermco belt furnace
- Thick film trimmer
- Thick film trimmer
- Multiple probe station
- Electronic instrumentation for circuit evaluation
- Packaging and sealing station

C. Artwork and Mask Making

This work will be carried out in four different rooms.

C1. Computer Aided Plotting Room

This 30 x 50 foot room was initially scheduled for all artwork but a more comprehensive computer aided graphics facility is being developed. Equipment includes:

- Gerber Scientific 1200 plotter with HP minicomputer tape drive (36 x 36 inch plotting surface with ink or photo exposure heads)
- Tektronix graphics terminal with hard copy capability
- Uniscope CRT terminal to the central campus UNIVAC 1108 computer

- Data General Eclipse S/130 minicomputer with video monitors and Varian Statos 42 high density electrostatic printer/plotter
- Lexidata color graphics terminal
- Digitizing table for generating check plots on Gerber plotter

C2. Manual Graphics

This will be done in the reduction room. Equipment includes drafting tables and a Unitech coordinatograph with digital read-out. Rubylith masks are produced with this system.

C3. Dark Room

This is a small dark room with modern developing sink temperature controlled water source, and ample storage cabinets and bench top space.

C4. Reduction Room

This room is part of the printed circuits lab and is equipped with a precision Dekacon reduction camera (36 x 36 inch mask mounting capabilities).

C5. Step and Repeat Room

This is an 8 x 24 foot class 10,000 clean room and is part of the silicon IC complex. It is equipped with two class 100 clean benches. One bench has a sink and hood for development and one bench is for a step and repeat camera. The first bench is equipped with compressed air, nitrogen blow gun, and a DI submicron filtered water.

It is hoped that a step and repeat camera will be added soon.

D. Printed Circuit Lab

This laboratory is equipped with benches, a fume hood and sink, and two spray etchers, water dryer, KPR developer unit, IR oven, dip coater, rinse unit, shear, pilot hole punch, drill press, light table, etc. Almost all of this equipment is new.

E. Other Equipment

The microelectronics laboratory has a wide assortment of electronic equipment for evaluation of semiconductor devices and circuits, including signal sources, meters, counters, curve tracers, scopes, etc. A partial listing of new equipment just purchased includes:

. 100 meg Hz Oscilloscope (Tektronics Mod 465);

. Sampling Oscilloscope (HP Mod 182C main frame with HP 1810A sampler);

. Digital to Analog Converter, HP 49303A;

. X-Y recorder, HP Mod. 7015;

. LRC meter, HP Mod 4332A;

. Precision multimeters, HP 3490A;

. Interface bus, HP 59310A;

. etc.

F. Supporting Laboratories

F1. Electro-optic Laboratory

This lab is equipped with a vibration free table, optical benches, detectors, lens, filter, optical radiation detector, two lasers (5 watt argon and 100 milliwatt Helium-Neon), and several items of standard electronic instrumentation.

F2. Communications Laboratory

This facility includes extensive electronic instrumentation for microwave measurements and for signal analysis. Equipment includes wave guides, slotted lines, microwave sources, UHF sources, wave analyzers, antennas, etc. New equipment will include a spectrum analyzer (up to 1.8 G Hz) and a vector voltmeter for s-parameter measurements. Also included are maximal length pseudo-random noise generators and bit pattern generators. The laboratory is located in two rooms on the fourth floor and has two antenna locations on the roof of the building.

F3. Instruction Laboratory

Two large rooms and several smaller rooms are dedicated to teaching and project laboratories. A wide variety of instrumentation, breadboarding equipment, logic trainers, power supplies, etc. are available for instruction, training and project work.

QUARTERLY

FINANCIAL REPORT

FOR

NASA CONTRACT NAS8-26749

December 1, 1978 - February 28, 1979

Prepared for

George C. Marshall Space Flight Center
Marshall Space Flight Center
Alabama 35812

Submitted by

J.D. Trotter, Principal Investigator
T.F. Wade
J.D. Gassaway

COST ANALYSIS OF RESEARCH PROJECTS

CONTRACT 30-45-0210607-232 PROJECT TITLE NASA Contract NAS8-26749

DATE THIS REPORT December 1, 1978 THROUGH December 31, 19 78

	EXPENDITURES THIS MONTH	EXPENDITURES TO DATE	OUTSTANDING COMMITMENTS	FREE BALANCE	TOTAL PROPOSED BUDGET
A. PERSONNEL SERVICES (1) Professional					$22,806
(2) Graduate Assistants					8,550
(3) Undergraduate Assistants					1,680
(4) Technical					
(5) TOTAL PERSONNEL SERVICES	2,157.91	26,344.28		6,691.72	33,036
B. MATERIALS AND SUPPLIES		1,079.90		1,770.10	2,850
C. EQUIPMENT					
D. TRAVEL		998.08		1,554.92	2,553
E. EMPLOYEE BENEFITS		1,723.91		1,971.09	3,695
F. OTHER (Specify) Computer Service	448.20	661.28		2,338.72	3,000
COMMUNICATIONS		90.75		- 90.75	
G. TOTAL DIRECT EXPENDITURES					45,134
H. INDIRECT COST 45.0% of A(5)		7,963.20		6,902.80	14,866
I. TOTAL EXPENDITURES	2,606.11	38,861.40		21,138.60	$60,000

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COST ANALYSIS OF RESEARCH PROJECTS

CONTRACT 30-45-0210607-232 PROJECT TITLE NASA Contract NAS8-26749

DATE THIS REPORT January 1, 1979 THROUGH January 31, 1979

	EXPENDITURES THIS MONTH	EXPENDITURES TO DATE	OUTSTANDING COMMITMENTS	FREE BALANCE	TOTAL PROPOSED BUDGET
A. PERSONNEL SERVICES (1) Professional					$22,806
(2) Graduate Assistants					8,550
(3) Undergraduate Assistants					1,680
(4) Technical					
(5) TOTAL PERSONNEL SERVICES	2,180.35	28,524.63		4,511.37	33,036
B. MATERIALS AND SUPPLIES	28.10	1,108.00		1,742.00	2,850
C. EQUIPMENT					
D. TRAVEL	104.65	1,102.73		1,450.27	2,553
E. EMPLOYEE BENEFITS	542.23	2,266.14		1,428.86	3,695
F. OTHER (Specify) Computer Service	21.66	682.94		2,317.06	3,000
COMMUNICATIONS		90.75		- 90.75	
G. TOTAL DIRECT EXPENDITURES					45,134
H. INDIRECT COST 45.0% of A(5)	1,210.23	9,173.43		5,692.57	14,866
I. TOTAL EXPENDITURES	4,087.22	42,948.62		17,051.38	$60,000

NOTICE:

Complete annual financial statement (including no cost extension) will be presented in the final technical report.